Surface-Wave Tracing by Flat Optics

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Metasurfaces (MTSs) are thin metamaterials constituted at microwaves by a dense periodic texture of sub-wavelength elements printed on a dielectric slab. By averaging the tangential fields of the surface wave (SW), the MTS can be macroscopically described through homogenized impedance boundary conditions (BCs). Different sizes and shapes of the metallic elements implement different values of the surface impedance; therefore, media with variable propagation and dispersion properties can be engineered. This allows us to design devices with variable refractive index, such as lenses and beam forming networks with relatively low complexity to be used in antenna system.

The new possibilities offered by employing MTS for such devices create the need for a tool that is able to characterize the propagation of SWs along these complex media. A Flat Optics theory was recently proposed on this concern [Martini et al., IEEE Trans. on Antennas Propagat, Volume: 64, Issue: 1, Jan. 2016]. The space variability of the BCs imposes a deformation of the SW wavefront, which addresses the local wave vector along not-rectilinear paths. The ray paths are subjected to an eikonal equation analogous to the one for Geometrical Optics rays in graded index materials.

In this paper, we focus our attention on particularly simple devices constituted by a MTS with variable boundary conditions that exhibits an axially symmetric variation, either covered or uncovered by a metal plate. We will show that when the MTS exhibits a radial variability, the ray paths can be found in a very simple form and our technique provides a fast, yet accurate method to evaluate the trajectories of the rays propagating along both isotropic and anisotropic MTS. New beam-forming devices are suggested on this basis.

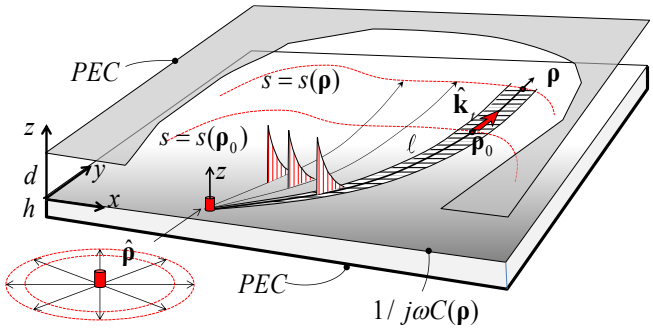

Figure 1 - Curved ray paths for a SW launched by a dipole source on an isotropic MTS with modulated reactance $X(\boldsymbol{\rho})$ inside a parallel plate waveguide.